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THE HISTORIC FLUCTUATIONS OF THE CASPIAN SEA.*

BY

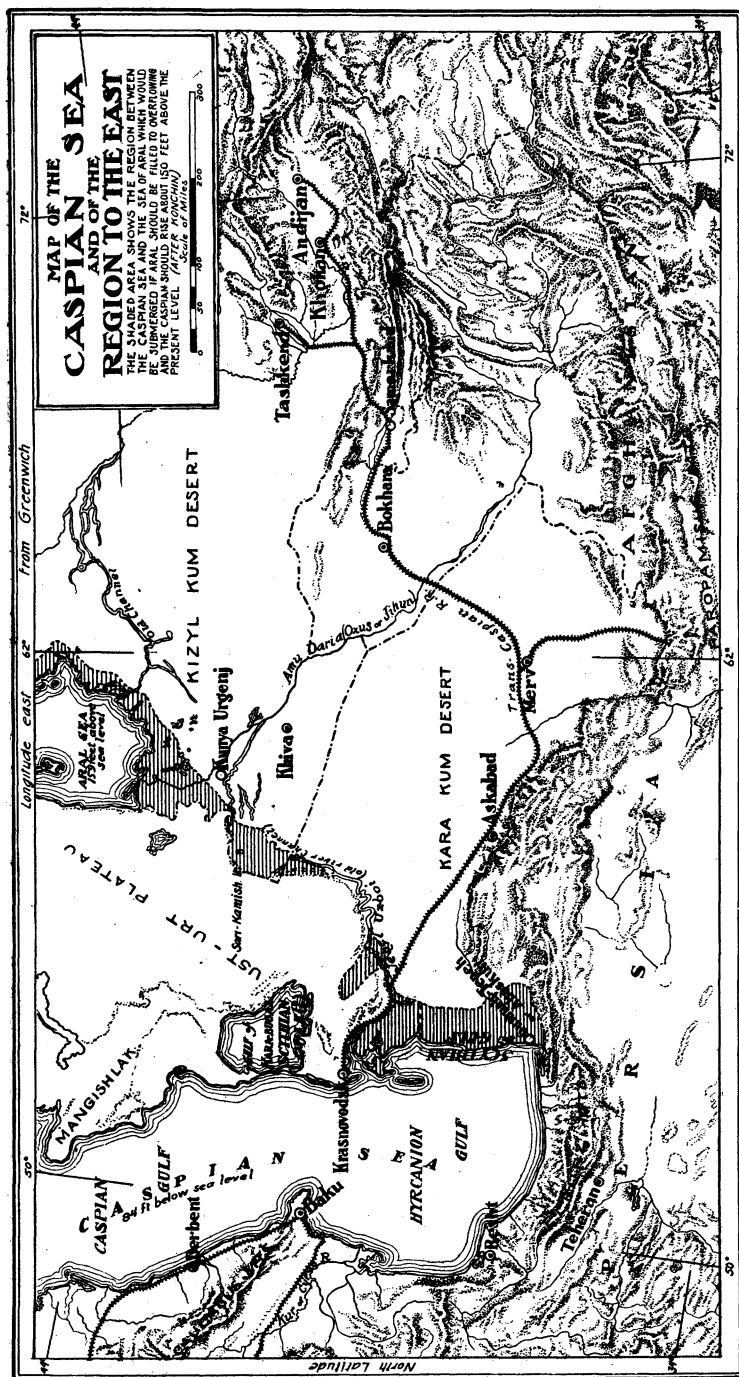
ELLSWORTH HUNTINGTON.

The fluctuations of the Caspian Sea and the nature of its connection or lack of connection with the ocean have been matters of discussion from the time of Herodotus until to-day. The possible overflow of the Sea of Aral to the Caspian and the alleged diversion of the Oxus River from the smaller sea to the larger have introduced complications which have rendered the problem very difficult of solution. Humboldt has devoted almost two hundred pages of his great work on Central Asia to the subject; Rawlinson has investigated it carefully; Brückner has made an exhaustive study of the fluctuations of the sea, especially during the last two centuries; and many other writers have contributed more or less to a discussion which began two thousand years ago, and in which no agreement has as yet been reached. Some writers have believed that a deflection of the Oxus River from one sea to the other is enough to account for all the recorded changes; others have appealed to movements of the earth's crust in explanation of the complex phenomena; and a few have assumed a progressive change of climate. None of these explanations has proved tenable, for the facts seem to show not only that there have been long epochs of high water alternating with epochs of low water, but that these have occurred without reference to changes in the Oxus River or to movements of the earth's crust. If, however, it be assumed that during historic times the climate of the Aralo-Caspian basin has been subject to *fluctuations* having a period of hundreds of years and decreasing in amplitude from the past to the present, all the phenomena appear to find a satisfactory explanation.

* This article is a modified chapter of the writer's book, entitled "The Pulse of Asia," soon to be published.

Among the ancients some considered the Caspian Sea a part of the great stream of ocean surrounding the habitable earth; others supposed it to be one of four symmetrical gulfs which were thought to penetrate from the northern and southern oceans into the dry land; while still others, who knew that it was an enclosed basin, inferred that it must have an underground outlet to the Black Sea, which, as a matter of fact, lies 85 feet *above* it. Previous to the days of Herodotus the Caspian Sea is mentioned only vaguely. Two ancient records, one Greek and one Egyptian, have been supposed to refer to it, and possibly to the Sea of Aral; and the traditions of the Argonauts have been thought to show that water communication existed between the Black Sea and the Caspian, but there is no certainty in either case.

Herodotus, about B.C. 458, visited Olbia on the Black Sea at the mouth of the Dnieper River. He there obtained from the merchants such accurate information that he was able to state definitely that the Caspian Sea was completely isolated and had no outlet. He makes the north and south axis six times as long as that from east to west, although now it is only between three and four times as long. Of course we have no certainty that Herodotus had anything more than the unreliable accounts of travelling merchants. Nevertheless, it is interesting to see how well his information agrees with the conclusion to which we are led by other evidence. The width of the Caspian Sea between the Caucasus Mountains and the Ust-Urt plateau, the part with which the Olbians would be most familiar, is about two hundred miles, and would not be greatly increased even though the level of the water rose several hundred feet. If the length of the sea were six times two hundred miles, water would extend from about its present limit at the foot of the Elburz Mountains on the south to north of Samara in the plains of Russia, and this is just what would happen if the level of the Caspian were about two hundred feet higher than it now is. Herodotus says, also, that the Jaxartes or Syr River, after throwing off many small arms to feed a lagoon, which Rawlinson surmises to be the Sea of Aral, entered the Caspian in a single stream. Possibly the Jaxartes may have followed an old channel which, as the map shows, joins the Oxus near that river's mouth; and the united streams may have flowed by another old channel, the Uz-boi, from north of Khiva to the Caspian. The data given by Herodotus as to the Jaxartes do not agree with those of his successors, which may mean either that conditions were subject to change or that the Father of History, at a distance

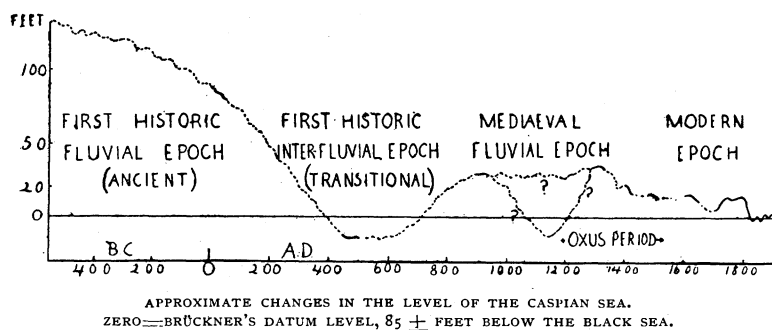


of fifteen hundred miles from the Jaxartes, could not obtain exact information.

Aristotle, B.C. 348, the next authority on the Caspian Sea, follows Herodotus strictly. A few decades later Alexander and his generals commissioned some of their subordinates to study the geography of the new regions to which the Greeks had lately penetrated. The geographers did not visit the northern side of the Caspian, but confined themselves to the southern shore south of the Caucasus Mountains on the west and of what is now the Sea of Aral on the east. Aristobulus, the geographer of Alexander, is quoted by Strabo as saying that in the fourth century before Christ the traffic from India came down the Oxus River to the Caspian, into which the river apparently flowed; crossed the sea; went up the Cyrus River to its head; down the Phasis to the Black Sea, and so to Europe. A little later, about 300 B.C., Patroclus, the admiral of Seleucus, made a survey of the southern coast of the Caspian. According to his account, the Oxus and the Jaxartes rivers both entered that sea, the mouth of the one being two hundred and forty miles from that of the other. To-day both streams enter the Sea of Aral, their mouths being about as far apart as they were in the days of Patroclus. Under the present conditions of water-supply it might be possible for the Oxus to flow to the Caspian Sea without entering Aral; and even the Jaxartes might possibly pass the Aral depression without entering it; but if it did the Ust-Urt plateau to the west would force the river so far to the south that it would inevitably join the Oxus two or three hundred miles from the present shore of the Caspian. Therefore, under present conditions, the Oxus and Jaxartes could not possibly enter the Caspian Sea by separate mouths. If, however, the Caspian were to expand so as to coalesce with the Sea of Aral, or to be separated from it only by a short sound or river, the two seas might be regarded as one, and the conditions would agree with the description of Patroclus. The absence of any distinct mention of the Sea of Aral by either Greeks, Chinese, or Persians down to the time of Menander of Constantinople, A.D. 590, suggests either that no such lake existed, which is extremely improbable, or that it was regarded as a part of the expanded Caspian.

The reports of Aristobulus and Patroclus have been discredited, because these men, or some others of Alexander's followers, confused the Paropamisus Mountains of Afghanistan with the Caucasus range; and, finding the name of Don or Tanis attached to the Jaxartes, supposed it to be the Don or Danube of Europe.

Opinion is divided as to how fundamental their geographical errors may have been. They, perhaps, were wrong in saying that the Caspian Sea was a gulf of the northern ocean symmetrical with the Persian Gulf on the south, and, like it, separated from the main ocean by a narrow strait. Their mistake, however, if mistake it was, is not so great as it appears at first sight. Humboldt, Wood, and others have favoured the hypothesis that in ancient, perhaps prehistoric times, the Caspian and Aral seas formed a single body of water, which discharged to the north. The supposed outlet was from the Aral Gulf of the enlarged sea along what has now become a line of lakes leading toward the Irtysh River. The hypothesis lacks confirmation, but the physical features which have given rise to it may have given rise to the Alexandrine idea of a northern passage leading to the Arctic Ocean. It is not likely, however, that such an idea would prevail unless the Caspian had stood at such a level that it almost, or quite, coalesced with the Sea of Aral.



Another explanation of the Alexandrine error is possible. When the Greeks inquired as to the northern shores of the Caspian Sea, they would hear that the water stretched away indefinitely to the north, where a narrow channel, the almost motionless stream of the mighty Volga, up which ships can sail for nearly two thousand miles, led far toward the Arctic regions. Under the prevailing ideas as to the symmetrical distribution of sea and land, the geographers would naturally come to the conclusion that the Caspian Sea was a gulf of the ocean corresponding to the Persian Gulf on the opposite side. Such an error would be even more likely to spring up if the Caspian extended far to the north over the plains of Russia as the account of Herodotus suggests, and as it must have done if it were so expanded eastward that the Oxus and Jaxartes rivers both entered it.

The Alexandrine idea of a northern outlet of the Caspian Sea

remained almost unchallenged for nearly five centuries, until the days of Ptolemy. Diodorus of Sicily, B. C. 60, is the only author, so far as we know, who speaks of the complete isolation of the sea during this period; and he does so only incidentally. All the others appear to have accepted the Alexandrine accounts as superseding those of Herodotus and Aristotle. As no one visited the northern coasts of the Caspian, there was no means of ascertaining the error. Nevertheless, the later geographers add materially to our knowledge of the shape and size of the sea. Pomponius Mela, A. D. 40, says that it has three main parts—the Caspian Gulf to the north, the Hyrcanian to the south, and the Scythian to the east. A glance at the map shows that the Caspian and Hyrcanian gulfs are to-day easily recognizable. There is also a far smaller gulf on the east, that of Kara-Bugaz, which may be the Scythian Gulf. If the water stood fifty or more feet higher the Kara-Bugaz would not change much, but a larger and much more noticeable gulf would be formed to the south of Kara-Bugaz, and would be a notable feature. The individuality of the other gulfs would also be increased. The importance of the Scythian Gulf is confirmed by Pliny, who mentions it in A. D. 69. A little earlier, in A. D. 20, Strabo has recorded some data as to the distance from the mouth of the Phasis River in the Black Sea to that of the Cyrus in the Caspian, as to the breadth of the sandy plain on the west coast of the Caspian, and as to other features. His figures seem to show that at that time the sea stood at a higher level than now. From them Khanikof has estimated that in the first century of the Christian era the level of the Caspian Sea was eighty-five feet higher than now. If this is true, the southern of the two eastern gulfs, which was probably the Scythian Gulf, must have extended far toward the Sea of Aral, with which it may have coalesced at an earlier, higher stage.

The last ancient author who makes any important contribution to our knowledge of the Caspian Sea is Ptolemy, A. D. 160, one of the most accurate among Greek and Roman geographers. He abandoned the Alexandrine idea of a northern outlet, and asserted that the sea was completely enclosed. His map makes it over twice as long from east to west as from north to south. This is due—in part, at least—to the fact that all his east and west distances are exaggerated, especially in remote regions where accurate data were hard to obtain. It may be, however, that when he became convinced that the sea was not connected with the northern ocean, he supposed the so-called Caspian Gulf to be also a mistake, and

accordingly made the sea consist of only the Hyrcanian and Scythian gulfs.

Most of the information of the preceding paragraphs has been gleaned from Humboldt's great book, "*Asie Centrale*." In dealing with the records of ancient authors two mental attitudes are possible. One, exemplified by Murchison in his paper on the Caspian, assumes that the ancients were essentially wrong, and that their geographical accounts are worth studying only as literature. The other, exemplified by Humboldt, assumes that the ancients were much like the moderns, generally right as to facts of personal observation, but often wrong in their inferences, and not always careful to distinguish between the two, or between information acquired at first hand and that quoted from others. If we adopt the second attitude, it is impossible to reconcile the ancient accounts with the facts, unless we accept the hypothesis that in the days of Herodotus and Alexander, over twenty-two hundred years ago, the Caspian Sea stood from a hundred and fifty to two hundred and fifty feet higher than now, and almost coalesced with the Sea of Aral. Three or four centuries later, at the beginning of the Christian era, the water had apparently fallen to a level a hundred feet or less above that of to-day, the sea being still much larger than at present.

It is not possible as yet to connect any physiographic evidence directly with the high stand of the Caspian Sea which we have inferred from the data of history. Nevertheless, as I saw in 1903 when travelling with Professor W. M. Davis, the sea is bordered by abandoned strands lying at various heights up to six hundred feet above the present water-level. The state of preservation of the lower strands shows that they are of very recent origin, though no one has yet succeeded in correlating them with any events of human history. Their weak development indicates that, as a rule, the sea did not stand at any one level for a long time. Other features, as Professor Davis has pointed out, suggest that the strands were formed by a lake which alternately rose and fell, as would happen during alternate fluvial and inter-fluvial epochs. At Jebel, on the Central Asiatic railroad, a hundred miles east of the terminus at Krasnovodsk on the Caspian Sea, we saw two particularly interesting strands at an elevation of two hundred and fifty and one hundred and fifty feet above the Caspian. The lower occupies the position where, according to the conclusion reached above, the shores of the Scythian Gulf stood in the days of Herodotus and his successors.

If we grant that such an expansion of the Caspian Sea is a fact

of history, the question arises whether it can be explained without postulating a change of climate. An increase in the amount of water used for irrigation during more recent times cannot be appealed to, for it is generally admitted that the population, and hence the consumption of water in the Aralo-Caspian basin, was greater in ancient than in modern times. Warping of the earth's crust will not explain the matter; for granting that the position of the sea may have been altered by this means, the water-spread, or surface exposed to evaporation, would remain practically constant so long as the climate remained constant. The water-spread of ancient times, however, appears to have been very great, possibly almost double that of to-day. Changes in the course of rivers are an equally inadequate explanation for the same reason. The Oxus and the Jaxartes are the only rivers which have been seriously suggested as possible contributors to the expansion of the Caspian Sea. Between them they furnish most of the water which balances the evaporation from the 26,000 square miles of the water-spread of the Sea of Aral. Even if they could avoid depletion by underground drainage into the basin of Aral, two hundred and twenty feet below the present level of the lake, they would still have to meet the losses incident to a course of nearly four hundred miles through the sandy desert without re-enforcement from tributaries before reaching the Caspian. On the way they would have to maintain a lake in the depression of Sari-Kamish (Yellow-Reeds), which lies in the course of the old Uz-boi channel, for its bottom is fifty feet below the level of the Caspian Sea. Having met all the losses, the united streams would by no means be able to add 26,000 square miles to the water-spread of the Caspian. The ancient expansion, however, amounted to far more than this. Apparently we must either disregard the ancient authorities entirely, or else admit a change of climate. The climatic hypothesis is supported not only by the agreement of the phenomena of the Caspian with those of distant regions, but by the evidence of old oases, such as those of Merv and Bal Kuwi, near Askhabad, where the ancient water supply seems to have been much larger than that of to-day. These two places appear to be typical of many in the Aralo-Caspian basin, where streams have diminished in size during historic times.

Returning once more to our investigation of the varying level of the Caspian Sea, we find a surprising change between the conditions in the first century of the Christian era and those of four or five centuries later. About the beginning of our era the trade route from Europe to India altered its course, as did the one from

China to the West. It ceased to go up the Oxus River, perhaps because the Caspian had so far contracted that the river no longer reached that sea, but fell into the now isolated Sea of Aral. The new route crossed from the mouth of the Cyrus River to the south-west corner of the Caspian, where in time there grew up a flourishing seaport, called Sokona, or Aboskun (Water of Oskun, or Sokona), at the mouth of the Gurgun River. The site of Aboskun is marked by the ruins of Gumush Tepeh, or Silver Hill, from which the so-called "Red Wall," a great bulwark against the Huns, stretches eastward to the mountains in a line of mounds a hundred and fifty miles long. The Caspian Sea, to quote Rawlinson, "must have been at a very low level when Aboskun and the great wall were first commenced, if it be true, as the Russian Surveys report, that remains of masonry along the line of the wall can be traced below water eighteen miles from the shore." O'Donovan and Eichwald also speak of the wall and of a caravan-serai of Aboskun which now lies under water. The most reliable and ancient Persian tradition, according to Rawlinson, relates that the wall was built by the Sassanian king, Firuz, against Kiyataleh, between A. D. 459 and 484.

At Derbent, on the western shore of the Caspian Sea, four hundred and fifty miles from Aboskun, there is a great wall of the same sort, supposed to have been built in the fifth or sixth century of our era. Its base is said to be slightly under water. In the Bay of Resht, according to Brückner, there are houses of unknown date standing in the sea, although they certainly were built on dry land; and Sokolof relates a Persian account of the ruins of a submerged city near the mouth of the Kur, or Cyrus River. Finally, at Baku we saw the towers of a well-preserved caravan-serai projecting above the water some distance from the shore. Their base lies fifteen feet below the level which Brückner has taken as zero in his investigations of the fluctuations of the sea. Lenz believes that the caravan-serai dates from before the founding of Baku in its modern site in the fifth or sixth century; but Brückner, on the basis of architectural resemblances, considers it of Arab origin, dating from the twelfth century. However this may be, the walls of Aboskun and Derbent are sufficient to prove that about 500 A. D. the level of the Caspian Sea was as low or lower than it is to day. The climate must then have been at least as dry as it is now.

During the succeeding Middle Ages there is unmistakable evidence that the level of the Caspian Sea again rose, though not to such a great extent as formerly. So far as the water-spread of the

mediæval sea is concerned, it is probably possible that the expansion of the sea may have been due to the deflection of the Oxus and Jaxartes rivers from the Sea of Aral to the Caspian. There is evidence that such deflection took place, or, at least, that part of the water of the rivers was so deflected. Hence it is necessary to proceed with the greatest caution, in order to ascertain whether the expansion of the lake occurred independently of the changes of the rivers. The chief evidence, one way or the other, is found in the works of various Arab and Persian authors quoted by Humboldt and Rawlinson. I shall assume that these Oriental authors are correct, unless there is clear reason for doubting their information.

During the Dark Ages, in the seven and a half centuries between the time of Ptolemy and of Istakhri, A.D. 920, war and confusion prevailed in the Aralo-Caspian region. The only addition to our knowledge of the two salt lakes is Menander's mention of the existence of the Sea of Aral as a great lagoon. With Istakhri, however, we enter upon a new era, a time when the Arabs and Persians rose to a high state of civilization and produced a literature of great excellence. They were especially proficient in geography and related sciences, and have left several works of high accuracy. One of the best of these is that of Istakhri. He corrected the Alexandrine idea of a northern outlet of the Caspian Sea, which, in spite of Ptolemy, was still prevalent. In a journey around the sea he came to Derbent, where he records that the old wall projected into the sea so far that six of its towers stood in the water. Brückner considers that there is good evidence that none of the towers have disappeared, and, therefore, concludes that about 920 A.D., at the time of Istakhri's visit, the Caspian stood twenty-nine feet higher than the modern mean level, or zero. Now, at that time the Oxus quite surely did not enter the Caspian. Istakhri's map shows it as entering the Sea of Aral, whose circumference is said to be one hundred parasangs (nearly four hundred miles). Moreover, Istakhri says distinctly, "Aral receives the Oxus, Jaxartes, and a number of other rivers. Nevertheless, one perceives no increase in its waters; and so one supposes a subterranean communication with the Caspian Sea." If he supposes *subterranean* connection, there manifestly was no visible connection. Elsewhere he speaks of the mouth of the Oxus as being ten days' journey, about two hundred and fifty miles, from that of the Jaxartes; but there is no hint of any connection with the Caspian. In describing the lake, he says: "On the shore itself of Aral there is a mountain called Sheghagher, on which snow remains from winter almost to the end of summer."

So far as I know, there is now no place near the Sea of Aral where snow stays so long.

The next important author, Edrisi, A.D. 1154, speaks of Aral as "a well-known lake," and confirms most of what Istakhri says, including the snow. He gives the distance, however, between the mouths of the Oxus and Jaxartes, in Lake Aral, as only ten miles. This, apparently, means that the Jaxartes had then changed its course to the old channel, already referred to in connection with Herodotus, a course which it appears to have followed intermittently. It flowed there as late as 1816. Of the Caspian Sea, Edrisi says that "it is elongated from north to south *less* than from east to west. [The italics are mine.] The two axes have the ratio of four to three." His map, however, shows it otherwise. It seems as if we had here a revival of the Scythian Gulf, either because Edrisi had read Ptolemy, or, more probably, because the rising water of the Caspian had once more broadened the southern end of the sea.

According to Rawlinson, "The Arab geographer Yacut [about A.D. 1225] furnishes the earliest record of the Oxus having found its way into the Caspian, after it had been turned into its old bed by the Moghuls at the siege of Urgenj [ancient Khiva] in 1221." Rawlinson, it should be said, believed that in ancient Greek times the Oxus flowed to the Caspian. Hence his reference to the "old bed" into which the Mongols diverted the river. Abul-feda, seventy or eighty years after Yacut, describes the Oxus and Aral in essentially the same way as Istakhri and Edrisi, with no reference to any connection with the Caspian. - Possibly the overflow of the Oxus to the Caspian lasted only a few years. A later writer, however, Hamdulla, the Persian, in 1325 A.D. tells us that Aboskun was then under water because the Oxus had been diverted from its old course about the time of the Mongols. He probably refers to the siege of Urgenj, and assumes that the water had remained high ever since, which may or may not have been true.

A few years before the date when Hamdulla wrote his account there had been another sudden rise of the Caspian Sea. This may have been due to a temporary diversion of part of the Oxus. Brückner tells us that, according to a story related by Marino Sanuto, the underground outlet by which the natives supposed the Caspian Sea to drain to the ocean was closed by an earthquake, whereupon the sea rose rapidly at the rate of about thirty-two inches a year, and some towns were submerged. Sheikh Sefi-Eddin says in reference to this that the water reached a certain

holy grave which lies thirty-seven feet above the present datum-level, and then, in the winter of 1306-7 began to fall. Now this date, be it noted, is within a year of the time when the Dragon Town on the shore of Lop-Nor was overwhelmed by the rising of that lake.* It is possible that an earthquake may have had something to do with the sudden rise of the Caspian, not by closing an outlet, but by diverting the Oxus. In view, however, of the similar rise of the lake of Lop-Nor over two thousand miles away to the east, it is more probable that at about this time there was a period of unusual rainfall, which caused the rivers and lakes to rise until the water of the Tarim River overwhelmed the Dragon Town, and that of the Oxus River broke from its old channel and flowed to the Caspian, causing a sudden rise of that sea. It was no such accident, however, which caused the original submersion of the ruins of Aboskun, as Hamdulla implies, for they were certainly under water at the time of Istakhri, four centuries earlier, when the Oxus did not flow to the Caspian.

Apparently, from 1221 A.D. onward for some centuries the Oxus bifurcated at certain times, one stream flowing to the Sea of Aral and one to the Caspian. Hamdulla, who has just been quoted, distinctly mentions such a bifurcation. He adds that the Sea of Aral had a compass of one hundred parasangs, from which it appears that the diversion of part of the Oxus had not materially diminished the lake. A century later a Persian writer, Sultan Shah Rukh, in whom Rawlinson puts much confidence, tells us that "in all ancient books the Lake of Kharesm [Aral] is described as the receptacle of the waters of the Oxus, but at the present date, which is A.H. 820 [A.D. 1417], the lake no longer exists, the Jyhun [Oxus] having made a way for itself to the Caspian, into which it disembogues at a place called Karlawn, or Ak-richeh." Elsewhere Shah Rukh repeats this assertion. He further says that, "The River of Khojend [the Jaxartes] in the lower part of its course, after passing into the desert of Kharesm, joins the Jyhun or Oxus, and thus ultimately reaches the Caspian." Rawlinson takes this to mean that the Jaxartes followed the old channel already referred to, branching southwest below Otrar, near Tumen, and joining the Oxus below Khiva, and that the united streams flowed to the Caspian through the Uz-boi, or old channel of the Oxus at the foot of the Ust-Urt plateau. If this is so the Caspian ought to have stood at a comparatively high level, as apparently it did, to judge from the following quotation from

* See the BULLETIN for March, 1907, p. 143.

Brückner: "Bakui informs us that early in the fifteenth century the sea swallowed up a part of the former city of Baku, and that in his time the water stood at the level of a still-existing mosque. Apparently we here have to do with an expansion of the sea and a subsequent standstill." The mosque stands sixteen feet above Brückner's zero.

In spite of Shah Rukh, one is inclined to doubt whether the whole stream of both the Oxus and the Jaxartes ever entered the Caspian, leaving the Aral to dry up entirely. At any rate, only fifty years later, in 1470 A.D., Said Abdul Hassan says that, "The River Amu, the great Jihun [Oxus], is the river which debouches in the Caspian Sea; it is also the Kharesm Jihun, which goes to Baheira Kharesm [the Sea of Aral]." Abdul-Ghazi, prince of Urgenj, or ancient Khiva, writing about 1632 A.D., gives a detailed account of certain changes in the Oxus. "In A.H. 880 [A.D. 1475] communication between Urgenj and the country of Abul-Khan [the Ust-Urtu plateau] was very frequent; because the River Amu [Oxus], after having passed under the walls of Urgenj, directed itself [along the Uz-boi channel] toward the eastern portion of the mountain of Abul-Khan, then toward the south following the base of the mountain, then toward the west. The river passed near Oghurja, and finally discharged its waters into the Sea of Mazanderan [the Caspian]." Again he says that in A.D. 1575, thirty years before his birth, "the Amu at Kara-Uighur-Tokai detached an arm [on the right] which passed the city of Tuk, and threw itself into the sea of Syr [Aral]. It was by this accident that the country of Urgenj has become a desert for lack of water. The place of the embouchure of the [new] river received the name Aral six months after the death of Essen [A.D. 1622]."

From the information given by Abul-Ghazi it is not clear whether the branch of the Oxus which in 1575 was diverted from Urgenj had formerly flowed to the Sea of Aral or to the Caspian. The account of Jenkinson, an English merchant who came down the Volga to the Caspian, and thence to Urgenj in 1559, indicates, however, that it flowed to the Aral. Jenkinson saw the mouth of the Uz-boi, and was told that formerly the Oxus discharged there, but had lately changed its course and gone back into the Sea of Aral. In coming to the Uz-boi, the Englishman sailed along the eastern coast of the Caspian near Mangishlak, and found deep water close to a shore where streams and trees abounded. To-day, as Rawlinson points out, the water is so shallow that no ship can approach the shore, and no one would think of describing the coast

as abounding in streams and trees. This suggests more abundant rainfall than at present, and a high stand of the water. It agrees with the atlas of Ortelius, dated 1562, which shows a deep gulf of the Caspian extending far toward Khiva—the Scythian Gulf once more.

After the days of Jenkinson the Oxus appears never to have flowed to the Caspian. Hanway in 1743, and later travellers, merely heard traditions of the drying up of the Uz-boi “a hundred years ago,” or “long ago in the days of our fathers.” Even before the time of Hanway, when Kitab Chelebi (Book Gentleman) wrote about 1650, the fact of the discharge of the Oxus into the Caspian was known only from books and tradition. Kitab Chelebi, commenting on the remark of Hamdulla (about 1359) already quoted, that the Oxus flowed partly to the Sea of Aral and partly to the Caspian, remarks: “There exists an arm of the Jihun [Oxus] which, after having passed the capital Khowaresm [Urgenj, or ancient Khiva], enters a narrow, rocky valley called by the Turks Kerlawā [the Kerlawān of Abdul-Ghazi]. This arm afterwards forms a cataract, where it falls with a frightful noise. According to Hamdullah, this arm of the Oxus discharges into the Caspian. Ebn-Haukal and Abul-feda [both about 1300 A.D.] say that the embouchure of the Jihun is in the lake of Aral, but we may believe that it is only the principal branch of the river of which those authors have meant to speak.”

Kitab Chelebi speaks only as a commentator, and adds nothing to our knowledge or the relation of the Oxus to the Caspian, except in one respect. His mention of a cataract or rapids in the Uz-boi channel is in accord with what has been recorded by modern geologists. Several observers, to quote Davis, “have noted that the gentle southwestward descent of the channel is broken by the sills of rapids at several points, from which it may be inferred that the stream by which the channel was eroded did not endure long.” Moreover, the Uz-boi channel is “decidedly smaller than that of the Amu to-day,” from which it may be further inferred that it never carried the whole stream of the Oxus, and far less the combined Oxus and Jaxartes.

After the time of Jenkinson, A.D. 1559, the level of the Caspian still remained high, although, as we have seen, there is no evidence that the sea was re-enforced in any way by the Oxus. A sketch made in 1638 by Olearius shows that the sea stood then at the third tower of the wall at Derbent. Brückner says that, “according to Khanikof there is even to-day a clearly visible horizontal line of

disturbance, like an old strand, the same on which the sea of the representation of Olearius stands; and truly the great clearness of the line speaks for a very long stand of the water at this height." If the high stand of the water at this time were due to the inflow of the Oxus, which had come to an end over eighty years before, there could not possibly have been "a very long stand of the water at this height." Unless the climate were different from that of to-day, evaporation would have lowered the sea steadily year by year until it was reduced to its present level.

From the time of Olearius down to the present day, data as to the level of the Caspian become more and more abundant and trustworthy. As collected in Brückner's excellent summary, they show that there was a rather low stand early in the eighteenth century, followed by a somewhat higher stand till about 1820. Since that time the level has been low with many minor fluctuations, as is indicated in the diagram on page 581.

The evidence of the high stand of the Caspian Sea during the Middle Ages is so abundant that there is little need of citing the maps of the period. The majority were drawn in Europe, and are based partly on ancient and partly on contemporary materials. One shows a bifurcation of the Oxus; another shows the river as entering the Sea of Aral; and a third as entering the Caspian. The majority show an enlarged Caspian and no Aral. Humboldt says of them: "The maps of the Middle Ages, of which I have made a particular study, seem to indicate that the Scythian gulf of the Caspian [was] much more extended to the east than in our day, [and] has by mistake been made to include all the lake of Aral."

To sum up our conclusions as to the Caspian during the Middle Ages, there can be little doubt that the level of the sea has been influenced by changes in the course of the Oxus River. On the whole, however, the fluctuations of the lake do not correspond to the variations of the course of the river; and the influence of the Oxus appears to have been of minor importance compared to that of some other factor. At most only a part of its water ever seems to have reached the Caspian, and even that for only a few centuries from about 1200 to 1500 A.D. at the outside. The time is designated the "Oxus Period" in the diagram on page 581. It is probable, indeed, that the Oxus never flowed permanently to the Caspian, but only for a few score years at a time. As early as 920 A.D. the sea had attained a high level, but it was not till three centuries later that the Oxus was first diverted to it. Again, the last notable contribution of the river to the sea had come to an end before 1550,

but the sea remained at a high level till at least 1638. Thus it appears that the mediæval high stand of the Caspian was not due to the diversion of the Oxus, but to some other cause, and that cause appears to have been climatic.

If we accept this conclusion, the curve on page 581 may be interpreted as the climatic curve of the Aralo-Caspian basin. Except during the last two centuries the details are uncertain. There have probably been notable fluctuations of which we have no record. One such is suggested by the dotted line between 900 and 1200 A.D. If Brückner is right as to the date of the caravan-serai at Baku, a short dry period must have ensued after the moister period indicated by the account of Istakhri. Making due allowance for the defects of our knowledge, there remains a strong presumption that the Aralo-Caspian basin has passed through a double series of great climatic changes during historic times. During the period commonly called ancient, the climate was apparently damper and cooler than now. This first historic fluvial epoch gave place during the Dark Ages, Emerton's Transitional Epoch, to the first historic interfluvial epoch, during which the climate was warmer or drier than to-day. In the course of the next few centuries there was a change to the somewhat damper or cooler conditions of the mediæval fluvial epoch; and this in turn has been succeeded by the modern dry epoch.

The most significant feature of the climatic curve of the Caspian Sea is that it is applicable to the whole of western and central Asia. Two examples will show how the climatic hypothesis illustrated in the diagram throws light on and is confirmed by hitherto inexplicable phenomena of distant regions. Around the little lake of Son Kul, which we visited with the Kirghiz in the western Tian Shan Mountains, a thousand miles east of the Caspian Sea, Professor Davis and I found in 1903 the remains of a number of old irrigation canals. They were located on the mountain sides at an elevation of from 10,000 to 10,500 feet above the sea. As we concluded at the time,* "They must be hundreds, possibly thousands, of years old, since they are thoroughly graded, and are sometimes wholly obliterated for a space. They cannot be of extreme age, however, for many can still be traced throughout their entire length, although they lie across slopes of considerable steepness, where erosion is so rapid that such small features must soon be eradicated. They must be irrigation canals, for they contour around the hills, are broad enough to carry most of the water

* See the BULLETIN for Sept., 1905, vol. 37, pp. 529-530.

of the streams from which they diverge, and come to an end in places suitable for fields. The peculiar feature is that they lie at a great altitude, where there is now no agriculture, nor could be, it would seem. Snow falls at Son Kul, so the people say, during all but two months of the year. On the morning of July eighth, at the altitude of the upper canals, I walked on new snow which was said to have been a foot deep a few days before. The next morning, near the shore of Son Kul, below the level of the fields once watered by the canals, the ground was stiff with frost, and the little pools on the edges of the brooks were skimmed with ice. Moreover, if agriculture were possible under such conditions, irrigation seems unnecessary. In July the ground was saturated with moisture, and the natives told us that the grass is always green as when we saw it [in summer, at least]. The simplest hypothesis is that at some time since the human occupation of the country, the climate was warmer, and therefore drier than now; but this cannot be proved. In regions such as Transcaspia and Persia, there is strong evidence of a greater water-supply during antiquity. It is hard to reconcile the two sets of facts, but it may be that climate is more changeable than has been supposed, and that since the dawn of history man has passed through more than one change between colder and warmer, or moister and drier conditions. If this has been the case, the course of history must have been deeply affected by geographic causes as yet uninvestigated."

Now, in the light of three years' further study, it seems probable that the canals were built during the first historic inter-fluvial epoch, probably between 300 and 800 A.D. If the climate were then so warm and dry as is indicated by the low stand of the Caspian Sea, agriculture would have been possible, and irrigation would have been necessary in places like Son Kul which are now too cold and wet for either. The people who were forced out of the warm, dry lowlands by increasing aridity would naturally betake themselves to available spots in the highlands. They could not practice agriculture long at Son Kul, because the succeeding mediæval fluvial epoch caused the climatic conditions to become unfavourable once more at a high elevation; although at lower elevations the habitability of the country became much greater.

A second illustration of the manner in which the climatic hypothesis, as exemplified in the curve of the fluctuations of the Caspian Sea, throws light on difficult problems is found in Turkey. Two thousand miles west of Son Kul, the Armenian lake of Gjoljuk, twelve miles long by two or three wide, lies at an elevation of

4,000 feet among the Taurus Mountains between the headwaters of the Euphrates and Tigris rivers. In 1899 and 1900, when I mapped and sounded the lake, it overflowed throughout the year, and formed one of the most remote sources of the Tigris. Those years, however, were a time of unusually large rainfall, not only in Turkey, but in the continental regions of the world as a whole. In drier years the lake is said to have no overflow during the long, rainless summer. In 1879, which was also a time of comparatively large rainfall, Tozer records that the water had recently begun to overflow. During most of the last century, however, the lake must have stood at a lower level, for the natives are unanimous in saying that previous to 1878 the water—sometimes, at least—stood many feet below the present strand. The impregnation of the clear, blue water with borax also indicates that the lake has been without an outlet much of the time recently. The borax comes chiefly from some large deposits about three miles east of the lake. Its amount is not so great as to render the water undrinkable, or even distasteful, if one is thirsty; and animals drink from the lake freely. Apparently, under the present climatic conditions, the lake is on the dividing-line between a so-called normal fresh-water lake with a permanent outlet and a salt lake with no outlet.

In former times the lake of GyoIjuk appears to have fluctuated in size repeatedly, in the same fashion as the Caspian Sea, and the lakes of Seyistan, Lop, and Turfan. Deposits of sand and gravel, alternating with black, humus soil, bear witness to at least three pairs of successive fluvial and interfluvial epochs. These, probably, belong to prehistoric times. The first historic account of the lake is that of Ptolemy, in the second century of our era. He calls it Lake Thospitis, apparently equivalent to the name Dzopk, by which the Armenians still know it. He merely says that it lies four degrees—actually three—west of Lake Arsissa, the modern Van, and that the Tigris River flows from it, which is exactly what a modern geographer might say. Apparently the condition of the lake at that time was much the same as it is to-day.

Later, however, there appears to have been a change. Near the south shore of the lake there is a little island on which stand the ruins of an old Armenian monastery. Around it the stone houses of an ancient village can be seen, submerged in water to a depth of twenty or thirty feet. Local tradition, recorded in a book preserved, till the massacres of 1896, in a neighbouring Armenian village, relates that the monastery was built about A.D. 500, or 600, at which time the island was part of the mainland. The

present bed of the lake, so the record goes, was a cultivated plain, through the middle of which flowed a stream. The stream disappeared at the lower end of the plain, but reappeared beyond the mountains, where it joined the Euphrates. Gradually the underground exit was closed with silt, and the plain was converted into a lake. The reduced size of the lake at some historic period is proved not only by the old Armenian monastery, but by a line of old forts. The forts, which are from one to two thousand years old, plainly mark the course of an important road from Harput to Diarbekir, running directly across what is now the bed of the lake, at a point about four miles from its western end.

As to the supposed underground outlet, I could find no proof of its existence, though I searched diligently. Nevertheless, in spite of the improbability that a lake which had existed for ages, as is shown by its deposits in deltas and beaches, should be drained by a temporary underground outlet, which soon became clogged again, I accepted such an hypothesis in 1900 as the most probable explanation. The only alternative seemed to be the hypothesis of a change of climate, which I then thought "contrary to the facts of history." Now, however, I am inclined to believe that it accords with the facts of history. The fact that the fluctuations of Lake Gyoljuk agree so closely in time and character with those of the Caspian Sea, and that a single hypothesis explains both, gives good ground for believing that Turkey has been subject to the same changes of climate which have affected Central Asia.

The extent and possible significance of these changes will be manifest from a brief résumé of the main conclusions arrived at in this article, and in others published previously in the *BULLETIN* and in the *Geographical Journal*. Including Gyoljuk, there are thus far six distinct basins in which the evidence of climatic change has been investigated. On the west lies Gyoljuk in Turkey; then comes the Caspian basin in Russia, and that of Seyistan to the south in Persia; while far to the east we have Lop and Turfan in the heart of Asia forming part of China, and Kashmir south of the Himalayas in India. If we omit the Volga and the European portions of the Caspian drainage area, the limits of our six basins lie over sixteen hundred miles apart from north to south, and over three thousand from east to west. All this vast area seems to have been subject to the same great waves of climatic change.

In the ancient days, when the Oxus River entered the Scythian Gulf of the expanded Caspian Sea, and Lake Gyoljuk discharged permanently to the Tigris, the lake of Seyistan had not yet been

converted into dry land by the giants, as the legend runs. Kashmir was so cold and snowy that agriculture was impossible; its people, according to tradition, were nomads, who were obliged to drive their flocks southward in winter to the warm plains of India. In the Lop basin an opposite state of affairs prevailed, and conditions were highly favourable. The rivers were full of water; Lop-Nor was *the* "Great Salt Lake," the desert was comparatively small and the zone of vegetation extensive; and on all sides there was a density of population and a degree of prosperity far beyond those of to-day. And in the Turfan basin the same was probably true.

A great change took place throughout the six basins during the early centuries of the Christian era. The lakes of Gyljuk, Seyistan, the Caspian Sea, Lop-Nor, and presumably Turfan were greatly reduced in size. In the case of the first three, parts of the old lake-beds were utilized as sites for villages. Except in Kashmir, the change in climate appears to have brought disaster, although in Turkey the question has not yet been investigated. In the other regions scores of once prosperous oases were abandoned for lack of water. A few of the displaced inhabitants probably went into the mountains and dug canals such as those of Son Kul. Others, perhaps, went to Kashmir, which now became warm enough for agriculture, and hence able to support a far larger population. And the rest must have been impelled to start hither and thither in waves of migration to confound the civilized world.

Again there came a change. The process of desiccation gave place to a slight but important tendency toward increased rainfall and lower temperature. Kashmir became colder and more snowy, and hence more isolated; the rivers of Lop and Turfan gained greater volume; and the lakes of Gyljuk, Lop, the Caspian, and Seyistan expanded once more. The habitability of the arid regions began to increase; migrations came to an end; and Central Asia was prosperous for a time. Finally a latest and slightest change took place in the other direction, and we seem to-day to be in the midst of an epoch of comparative equilibrium, with no marked tendency toward climatic change in either direction.